Wideband

Wideband is a high-speed link between the RDA and RPG used to transfer massive amounts of data quickly (refer back to fig. 2-25). It also conveys system commands to the RDA (recall, system commands originate at the UCP). Should this crucial link be broken, all antenna functions halt, the processing of real-time data ceases, and communications to and from the RDA are terminated. Wideband link may consist of either hard-wired (direct cabling) to the RPG, or a fiber optic connection. The type of connection used depends largely on distance.

Narrowband

Narrowband consists of a series of dedicated telephone lines that link all remaining components (PUPs) to the RPG (refer back to fig. 2-25). It is primarily used to disseminate products to users and relay UCP commands to the appropriate radar component. Narrowband also carries message traffic between the UCP operator and system users.

If a single narrowband link becomes disabled, only that specific user (PUP) is affected. Since dial-in capability exists, impact to the user is minimal. All access ports on the RPG are designated as either dedicated for APUPs and PUPS or dial-in for part-time users.

NATIONAL WEATHER RADAR NETWORK (NWRN)

The National Weather Radar Network (NWRN) is a composite of WSR-88D sites from around the country. Each site is tasked with the challenge of continuous collection of radar data while ensuring the availability of WSR-88D products to all system users. Currently, this network consists of over one hundred sites providing nearly complete coverage of precipitation and severe weather events throughout the u s .

The NWRN increases the WSR-88D's versatility and establishes greater flexibility for system users. The NWRN allows users to access far away sites, providing live data for aircrew briefings and other types of mission support. Connections are made via commercial phone lines; therefore, access to a remote site defines you as a non-associated user (NAPUP). Once contact is terminated, you can freely return to your host system as an APUP. This capability is a breakthrough for weather briefers as it improves aviation safety. Before its existence, the availability of radar data was extremely limited. Radar charts were often old and unrepresentative of current conditions.

WSR-88D systems have been installed in parts of Alaska and at various sites throughout the Pacific, allowing for even more versatility. For example, you may be stationed stateside and be asked to brief your commanding officer on tropical storm conditions in Guam. As a non-associated user, you can examine live radar information for storm movement, strength, and wind velocity. You can also analyze for tornadic activity, squall lines, and other severe weather signatures-all from the safety and comfort of your own weather office thousands of miles from the event. This is all made possible through the WSR-88D's advanced communications system. Note that any WSR-88D site that is located outside of the conterminous United States (CONUS) is considered a non-network site.

In addition to the WSR-88D PUP workstations, a Supplemental Weather Radar (SWR) is being installed at selected weather stations overseas that do not have access to information provided by the WSR-88D network. The SWR is a commercially developed Doppler radar capable of providing real-time radar surveillance. It consists of a mini antenna and a desktop workstation similar to a WSR-88D PUP. It also produces interperative products similar to the WSR-88D.

ARCHIVING

Archiving is simply the process of preserving data for long-term storage. As information passes from one component to another, archiving may be accomplished in different formats. The WSR-88D uses two types of storage devices, an 8mm magnetic tape and a 5 l/4-inch optical laser disc. The act of archiving occurs at four locations throughout the system. These are identified as Archive Levels I, II, III, and IV. Archive Levels I and II are accomplished at the RDA. This archived data consists of system maintenance information and digital base data from the signal processor. The Archive Level III interface is located at the RPG. At this level, all products produced by the RPG can be saved. The Archive Level IV interface is located at each PUP. Only data available at the PUP may be recorded at Archive Level IV, at the discretion of the user.

VOLUME COVERAGE PATTERNS

Smart scanning strategies are extremely important in optimizing the WSR-88D's detection capability. Unlike older units, the WSR-88D has several different operating modes that can function automatically and continuously. The antenna is also capable of scanning (rotating) at several different elevation angles.

The WSR-88D has a beamwidth of 1° and thus creates 360 "beams" or *radials* of information per elevation angle. The area covered by one complete 360° rotation at one elevation angle is called an elevation scan. The area covered by the radar beam as the antenna rotates through **several** elevation scans (0° through 20°) is known as a volume scan.

The RDA can invoke computer-driven instructions known as *Volume Coverage Patterns* (VCPs). VCPs determine how thoroughly the atmosphere is to be scanned. They dictate the number of areas to scan, the specific elevation angles to examine, and the time allotted for this task. The scanning process is repeated indefinitely, or until a change in VCP is made. Some products may be displayed after just one elevation scan. Thus, each "slice" of the atmosphere is immediately available for examination. Other products are not available until all elevation angles have been scanned for that particular VCP. These products are called *volumetric* products because the entire volume of radar coverage must be scanned before they can be produced.

Two operational modes exist with the WSR-88D: mode A *(precipitation mode)* and mode B *(clear air mode)*. Each mode contains two VCPs designed specifically for that type of environment. Each VCP possesses certain capabilities, as well as limitations.

Mode A (precipitation mode)

Mode "A" is used during periods of precipitation and convective activity. This mode consists of two short pulse (1.57 microsecond) modes, VCP 11 and VCP 21.

VCP 11.—This pattern scans 14 elevations in 5 minutes. It contains fewer data gaps than other VCPs. This increases radar accuracy, making VCP 11 a logical choice for examining nearby storms. VCP 11 provides the most complete coverage of all VCPs, and it is normally used when significant echoes are present or severe weather is occurring or anticipated. Weather events are more accurately depicted on final products.

Unfortunately, VCP 11 requires a high degree of data processing, significantly increasing RPG workload.

VCP 21.—This scans nine elevations in 6 minutes. It provides adequate coverage for non-severe events (continuous rain, drizzle). Increased data gaps (less scans) effect performance close to the RDA. However, adequate coverage is provided for distant storms.

Mode B (clear-air mode)

"Clear-air" does NOT imply cloud-free skies, but rather the absence of precipitation from radar. In other words, the criteria for the WSR-88D to use the precipitation mode (VCP's 11 and 21) has not been met over the coverage area of the radar. Mode "B" contains VCPs 31 and 32; both complete five elevations in 10 minutes, both scan slower than mode A, and both contain larger data gaps than VCP 11 or 21. However, in precipitation-free environments, these VCPs are extremely helpful in detecting the early formation of convective precipitation. They are also helpful in detecting air mass discontinuities and monitoring precipitation onset.

VCP 31.—This pattern contains the longest pulse (4.7 microseconds) and the lowest PRF of all VCPs (recall, a longer pulse contains more power and increase sensitivity). VCP 31 scans slowly, to allow sufficient return of energy from clear-air scatterers. The greatest drawback to using VCP 31 is its reduced Doppler capability. While winds and motions are still observed, stronger winds are more likely to alias when scanning with VCP 31.

VCP 32.—This pattern uses relatively shorter pulses and a higher PRF than VCP 31. It remains sensitive enough to observe most scatterers while increasing Doppler thresholds in clear-air mode. Of course, the weakest features may be lost.

In clear-air mode, the decision to use VCP 31 or 32 (long pulse vs short pulse) is dictated by the meteorological situation and is not always an easy choice to make. For example, on windy days where ample scatterers are present (clouds, moisture, etc.), VCP 32 may be the best choice. Its shorter pulse makes it less likely to alias velocities. When the atmosphere contains few scatterers, such as on cold, dry days, longer pulses may be required (VCP 31).

The radar makes some decisions by itself. The WSR-88D is designed to operate continuously in "B" mode, but switches automatically to "A" mode whenever precipitation is detected. Precipitation is

classified as the return of reflectivity values greater than or equal to 18.0 dBZ. A return to the "Clear Air Mode" must be manually selected at the UCP.

Q44. *The antenna of the WSR-88D is part of what major system component?*

Q45. *Which hydrometeor would provide higher dBZ values, hail or drizzle?*

Q46. *The RDA is capable of reducing or eliminating what type(s) of radar problems?*

Q47. *Which component of the WSR-88D contains algorithms that create products?*

Q48. *What is the difference between "base" products and "derived" products?*

Q49. *Which component of the WSR-88D does the observer or forecaster use to request and obtain products?*

Q50. *What is the primary input device when operating a PUP workstation?*

Q51. *Most Navy and Marine Corps stations with Principal User Processor (PUP) workstations are classified as being what type of WSR-88D system user?*

Q52. *WSR-88D narrowband links are maintained by what mode of communication?*

Q53. *Data available at the PUP workstation is recorded at which archive level?*

Q54. *What is meant by the term "volumetric product"?*

Q55. *Which operational mode and volume coverage pattern should be selected when severe weather is present or expected?*

WSR-88D PRODUCTS

LEARNING OBJECTIVES: Identify how WSR-88D products are acquired. Recognize the difference between base data and derived data. Identify the more commonly used base and derived products. Identify the uses and limitations of base and derived products.

In this section, we will explain how products are acquired from the WSR-88D. Next, we discuss in detail the difference between base and derived data. We then examine some of the most commonly used products. Our operational overview of these products will include a simple description, along with a discussion of the purpose, strengths, and limitations of each product.

PRODUCT ACQUISITION

Products from the WSR-88D can be grouped into three general areas of application: precipitation measurement, storm warning, and wind profiling. These products become available to users in one of three ways. They are either specifically identified on a routine product set (RPS) list, solicited as a "one-time request" (OTR), or are automatically generated as an "alert" condition (alert-paired product).

Routine Product Set (RPS)

An RPS list provides an automated way of managing RPG workload. It allows associated users to identify and access routinely required products. Each PUP site tailors its own list according to mission requirements and modifies this list as needs change (via the UCP applications terminal). Each RPS list contains up to 20 products catalogued by name and distinguishing characteristics (i.e., elevation angle, range/resolution, etc.). Products found on the RPS list are generated every volume scan and then distributed to the appropriate user.

One-time Request (OTR)

Products that are not routinely needed are not usually placed on the RPS list. When such products are needed, associated users may obtain them via a one-time request. All one-time requests made by associated users will be honored by the RPG. Products not on the RPS list will be built on demand. With NAPUPs, however, this is not the case. Since non-associatedusers cannot increase the RPG's workload, new or unusual products are NOT built on demand for them. OTRs made by NAPUPs are only honored for pre-existing products stored in the RPG database.

Alert-paired Product

The WSR-88D is capable of producing alert messages, accompanied by audible alarms. Such alarms are sounded at each PUP site when prescribed conditions occur. Alert criteria are usually based upon severe weather parameters. All alert conditions are user-definable and should be established jointly since they affect each user of an associated RDA. Once criteria are established at the UCP, selected products, known as *alert-paired* products, will be transmitted automatically with each alert. These products aid in severe weather evaluation. Each PUP site receives both the alert message and any alert-paired products. This eliminates the need for one-time requests and allows forecasters to assess the situation rapidly. Alert messages and alert-paired products are given the highest priority by the system.

Significant weather events may be missed under certain circumstances. Thus, alert-paired products reduce the potential of operator oversight resulting from poor product selection. Alert-paired products might mean the difference between ample warning of severe weather or no warning at all. For example, if 50-knot winds will trigger an alert, a base velocity product would most likely confirm the phenomena and assist the forecaster in evaluating the circumstances surrounding that event. This saves time and provides forecasters with the best product for validating the alert occurrence.

BASE PRODUCTS

Recall that the WSR-88D creates two types of products: base and derived. Base products provide a broad overview of the meteorological situation and are the next best thing to viewing electromagnetic energy in its raw state. They graphically illustrate returned energy as reflectivity, velocity, or spectrum width data.

Base Reflectivity (REF) Product

As previously discussed, a radar measures the amount of electromagnetic energy returned to the antenna. The strength of this energy defines a target's intensity. With this in mind, it stands to reason that stronger intensities ofprecipitation from severe storms will contrast sharply from that of surrounding precipitation. In this respect, the WSR-88D truly pays off by transforming backscattered energy into useful, colorful, and interpretable displays.

The practice of displaying reflectivity values from backscattered energy is nothing new. However the process and methods used are becoming more sophisticated. The increased accuracy of the WSR-88D along with the addition of color, makes older radars obsolete. Color-coded targets placed on geographical background maps increase the effectiveness of radar interpretation by providing a clear and informative visual presentation. Operators can quickly compare target strengths and distinguish severe cells at a glance.

Figure 2-32 is an example of the Base Reflectivity (REF) product. Reflectivity data levels are indicated by the color scales found along the product's right margin. With base reflectivity, the data levels refer to target reflectivity intensity (dBZ). Rainfall rates can easily be estimated from REF. Reflectivities from light rain average around 20 to 25 dBZ, while reflectivities from thunderstorms average around 45 to 55 dBZ. Normally, it is difficult to distinguish precipitation type based on reflectivity alone. For example, snow and light drizzle both produce nearly the same reflectivity values. Very high reflectivity values are usually associated with hail. Although base reflectivity has a maximum range of 248 nmi, its best resolution (.54 nmi grid size) is limited to 124 nmi from the RDA. All range folded areas are displayed as purple shading.

Base reflectivity provides a weather snapshot of the entire radar coverage area. Highly reflective storm cores and embedded thunderstorms appear quite nicely in color. These same features were difficult to observe on conventional radarscopes.

Using base reflectivity, an operator can also identify distinct radar *signatures* and correlate targets to their geographical location. Radar signatures are visible patterns commonly associated with certain phenomena. Meteorologists have, over many years, linked a number of weather events with the signatures they produce. Classic radar signatures are often the key to identifying severe weather potential before it occurs. Some of the more important signatures are briefly discussed here.

HOOK ECHO.—The hook is a pendant-shaped echo, resembling the figure *6*. It is produced by precipitation being wrapped around a vortex. Therefore, hooks are typically associated with tornadoes. The hook is not the actual tornado; it is merely an indicator. The right/rear quadrant of a storm (with respect to storm movement) is the best place to monitor development, since tornadoes commonly
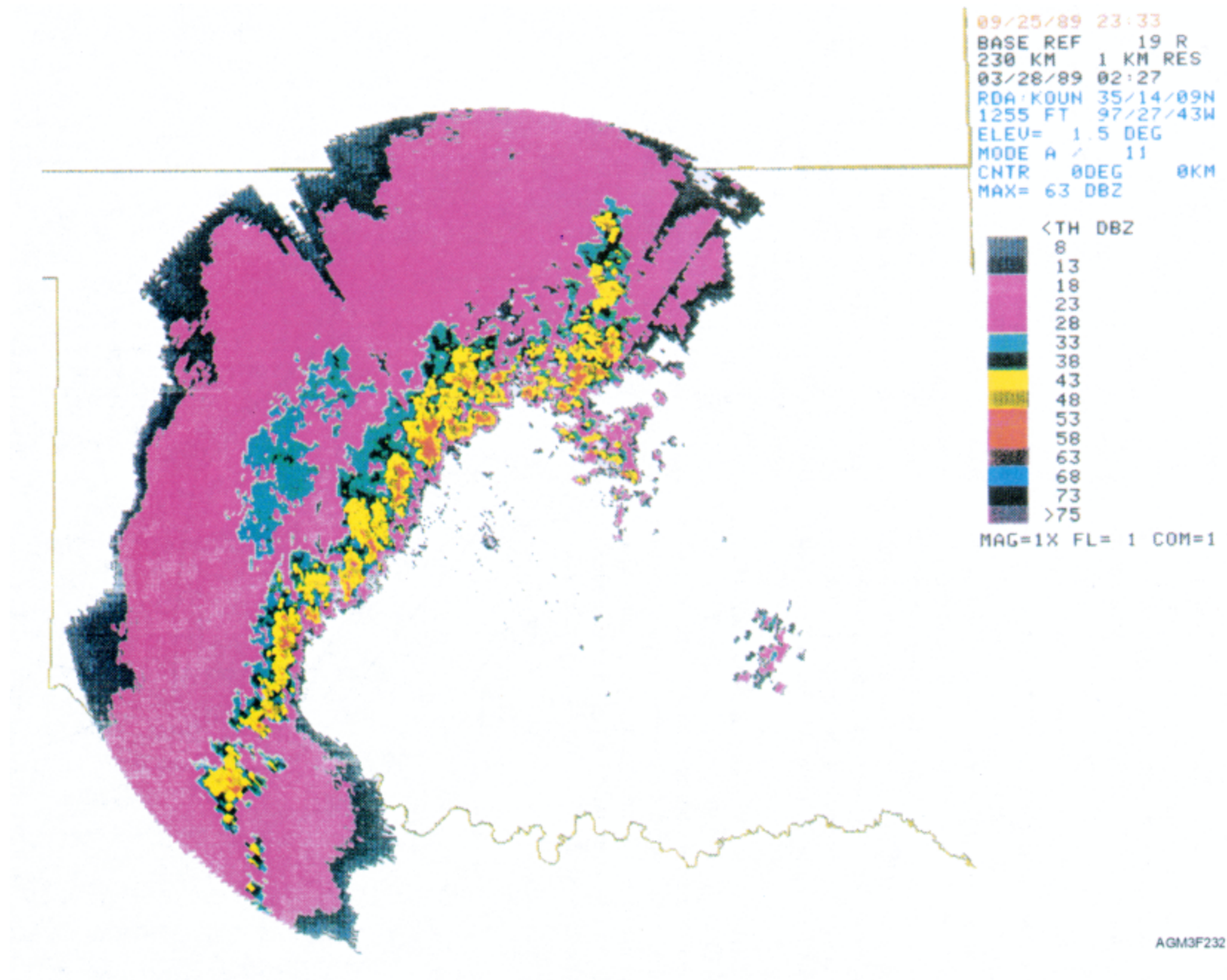
09/25/89 23:33
BASE REF   19 R
230 KM   1 KM RES
03/28/89 02:27
RDA KOUN 35/14/09N
1255 FT   97/27/43W
ELEV=   1.5 DEG
MODE A /   11
CNTR   0DEG   0KM
MAX= 63 DBZ

<TH DBZ
8
13
18
23
28
33
38
43
48
53
58
63
68
73
>75

MAG=1X FL= 1 COM=1

AGM3F232

Figure 2-32.—Base Reflectivity product.

form there. Figure 2-33 exhibits a classic hook signature.

Hook detection is difficult under any circumstances. Hooks are a small, short-lived feature, often obscured by surrounding storm mass. Due to beam broadening, distant hooks might be missed altogether. While the vertical extent of a tornado might exceed 35,000 feet, hooks are most commonly observed on radar at lower elevation angles.

WEAK ECHO REGIONS (WER).—A weak echo region is that portion of a storm exhibiting below normal returns. WERs are normally found at the storm's core. They are formed from the **absence** of water droplets and hail. As intensifying updrafts lift mass to greater heights, they create an area that is void of scatterers (no reflectivity). This area of weak echoes appears hollow within the storm. Notice the weak echo region forming in the lower portions of figure 2-34, view (A).

BOUNDED WEAK ECHO REGION (BWER).—If a WER continues to develop, it will eventually become bounded on all sides by much stronger reflectivities. This occurs as water droplets and hail exit the column at great heights, encircling the updraft core as they fall back toward earth. Bounded weak echo regions (BWERs) generally confirm storm

development and imply a transition to severe status (fig. 2-34, view B).

LINE ECHO WAVE PATTERN (LEWP).—A LEWP is simply a line of convective echoes that has become subjected to uneven acceleration. When this occurs, some portion of the line is propelled faster than other portions, causing the line to bend or arch. Because of accelerated movements, severe weather is a regular feature normally occurring ahead of LEWP, at and slightly south of the crest. With this in mind, position "2" in figure 2-35 stands at great risk of these fast-moving storms. The speed of the LEWP itself is a good indicator of its severity.

STRONG REFLECTIVITY GRADIENTS.—From a radar perspective, monitoring rapid changes can best be accomplished by monitoring reflectivity gradients (transition zones). For instance, if the temperature in Chicago is 55°F and the temperature in Biloxi is 65°F, the thermal gradient between these two cities is weak. However, if this same amount of change occurred between New Orleans and Biloxi, the gradient would be much stronger. For radar purposes, reflectivity gradients illustrate the sharpness, or contrast, between a storm and its surroundings. The sharper the gradient, the greater potential for severe weather. Enhanced resolution, color, and digitized displays make reflectivity gradients more observable than ever.
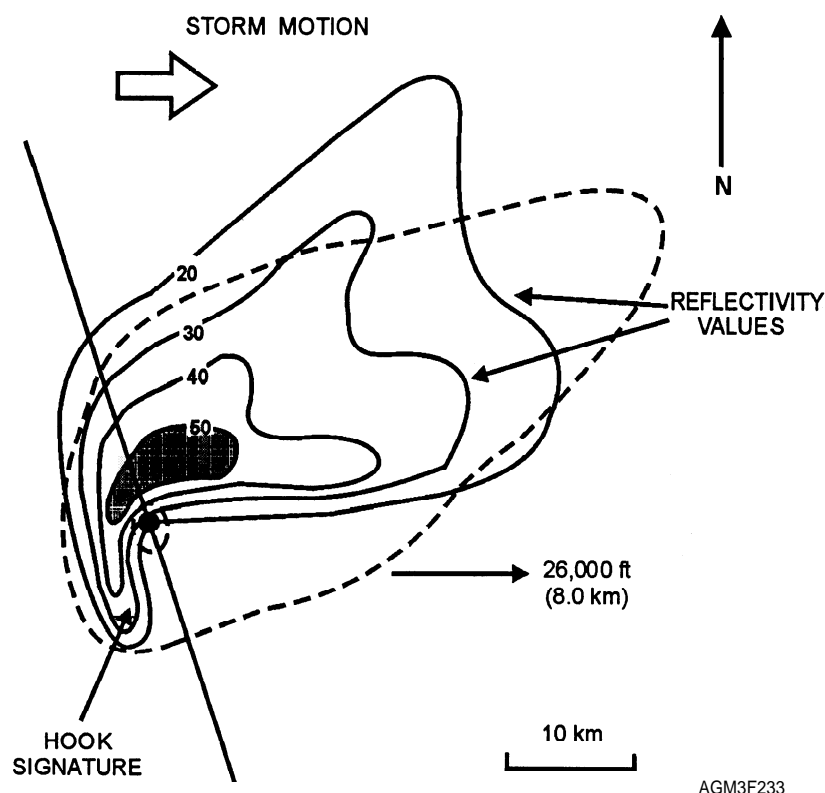

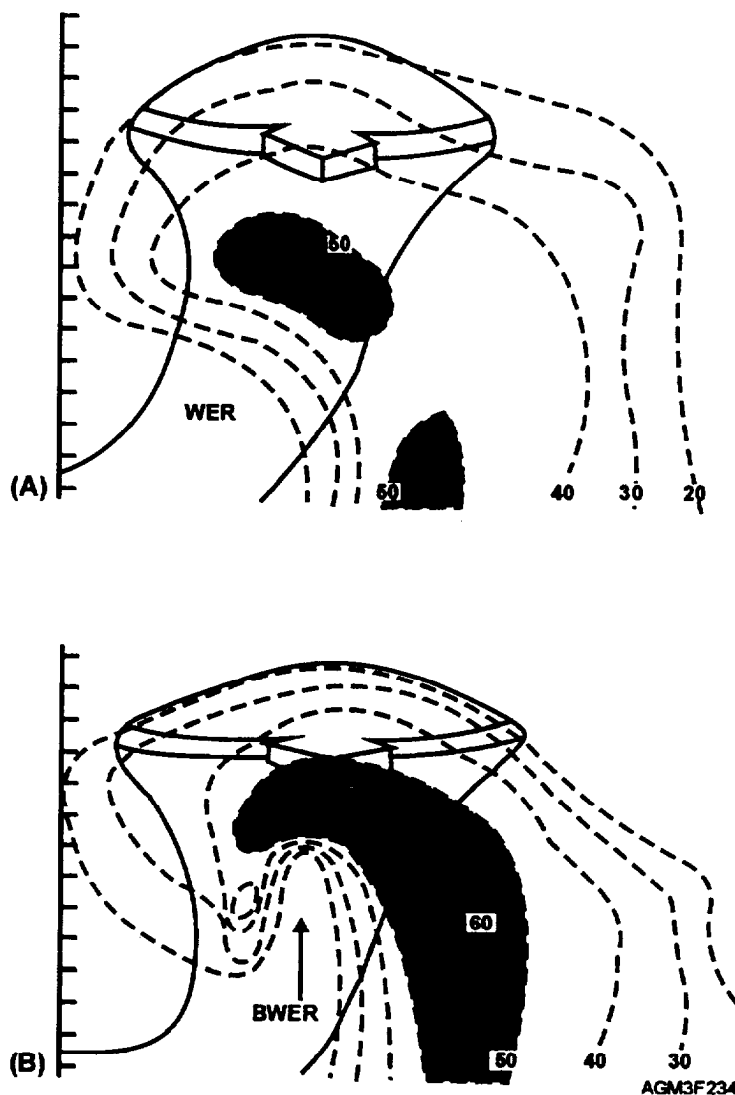**Figure 2-33.—Thunderstorm cell exhibiting a classic hook signature.**

Figure 2-34 .—Thunderstorm cell exhibiting (A) Weak Echo Region (WER), (B) Bounded Weak Echo Region (BWER).

We tend to place a great deal of emphasis on severe weather detection. However, reflectivity serves many other practical uses on a daily basis. For example, we know that precipitation produces a minimum of 18.0 dBZ reflectivity return. Therefore, returns of less than 18.0 dBZ might be attributed to nonprecipitable cloud droplets or other minute scatterers. From this we can estimate cloud heights (bases, tops), the thickness of cloud layers, and the height of the freezing level (altitude at which the air temperature equals 0°C).

In addition, reflectivity can also be used to locate *the melting* level. The melting level is very close to and just below the freezing level; therefore, the melting level is slightly warmer. As frozen particles descend through the melting level, they become lightly coated with water. This makes them highly reflective and produces returns that are stronger than either the frozen particles above or the liquid droplets below. When stratiform clouds are present, the melting level appears as a halo around the RDA (referred to as the bright band).

Keep in mind that the presence of either ground clutter, anomalous propagation, or hail can significantly contaminate reflectivity data and all products built from such data. The Base Reflectivity product may be severely biased, resulting in exaggerated intensities. The product can become deceiving, indicating the presence of strong storms, which may or may not be real. Range folded areas can also cause misinterpretation or obscure valuable data
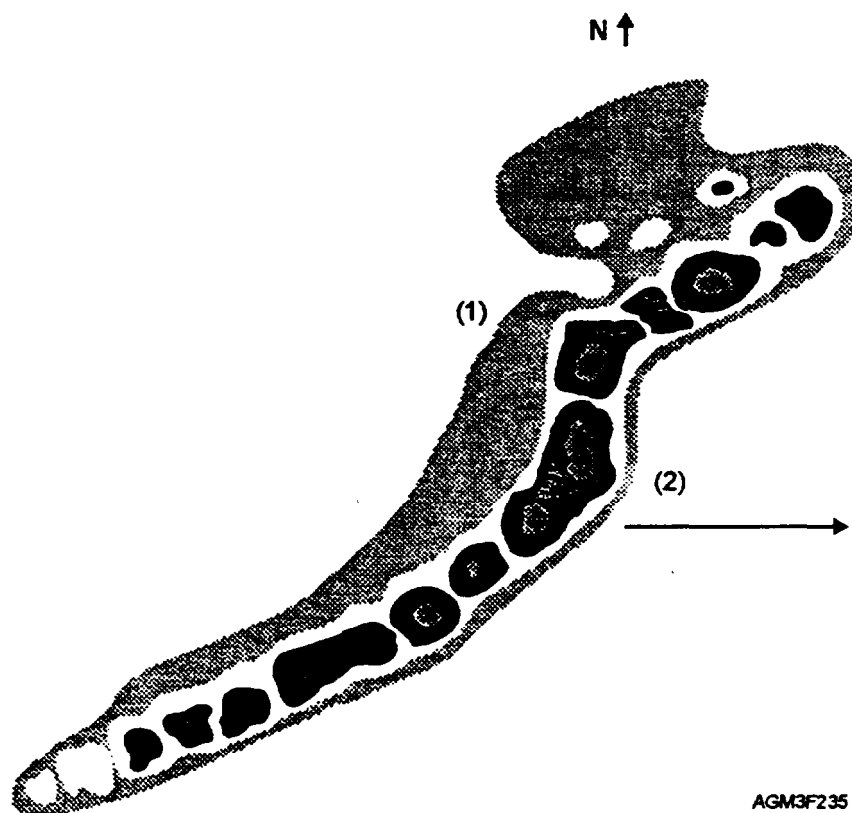
Figure 2-35.—Line Echo Wave Pattern (LEWP). Uneven acceleration causes the line to crest at position (1) and bulge at the point of acceleration, position (2).

beneath the purple shaded areas. And, as with all radar products, successful coverage depends on the availability of scatterers.

Base Velocity (VEL) Product

Doppler radar measures only the radial component of motion (directly toward or away from the antenna). The Base Velocity product (VEL) presents the **mean** radial velocity data. While only two-dimensional data is received, a pseudo 3-D analysis is displayed. Weather features are extracted in both the horizontal and vertical, producing valuable information. As with Base Velocity, a separate product is available for each elevation angle in the current volume coverage pattern (VCP).

The Base Velocity (VEL) product can be used to examine internal storm motions, as well as overall atmospheric flow. In the horizontal, this includes convergence, divergence, rotation, and wind shifts. In the vertical, this product helps locate low and mid-level jet streams and inversion layers. Base Velocity is also useful in locating aviation hazards, such as turbulence and low-level wind shear (LLWS). Any

range folded areas, as on base reflectivity, are displayed in purple.

All velocity data from this product must be referenced to a "zero-Doppler" velocity line. The zero-Doppler velocity line depicts points along the radar beam where no Doppler motion is being detected. Remember from our discussion of velocity that this does not mean that no motion is occurring. It simply implies that motion in this region is not being detected by the radar.
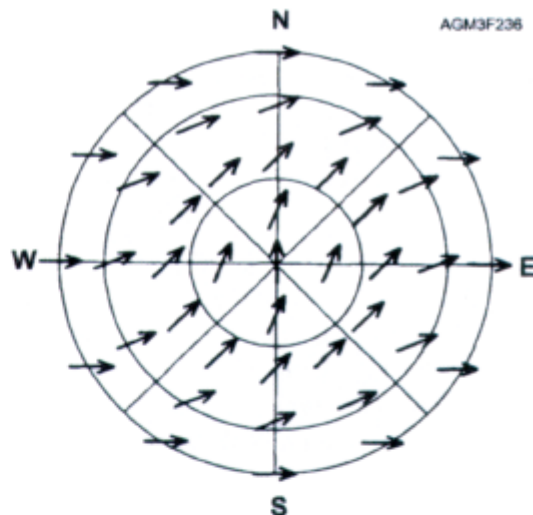
Doppler velocities are color-coded while wind directions are not. Cooler colors, such as blues and greens, depict velocities moving toward the antenna (negative values). Conversely, warm colors (red, orange, yellow) are outbound (positive values). Gray colors indicate where the wind component is perpendicular to the radial direction from the radar (zero velocity). Determining the wind direction from Base Velocity data can be difficult and requires practice.

Look at figure 2-36. View (A) shows a vertical profile of uniform wind speed that veers with height. View (B) depicts the same general wind field as it
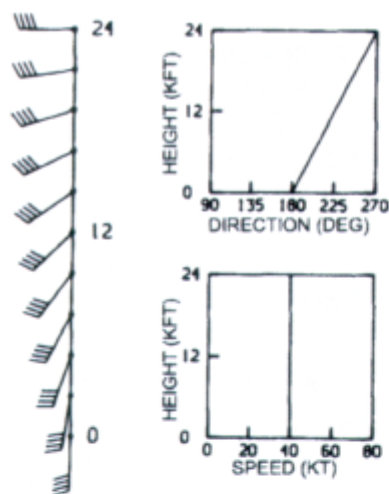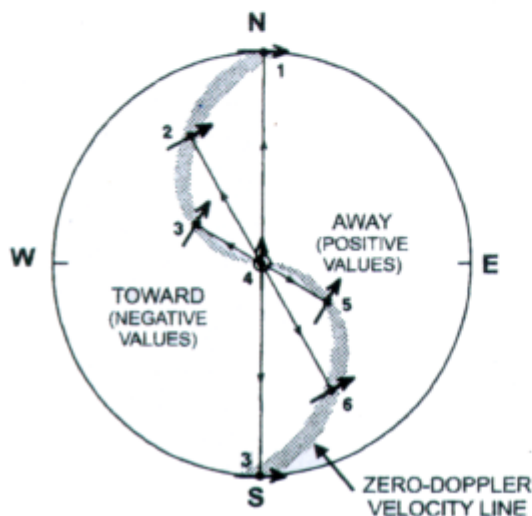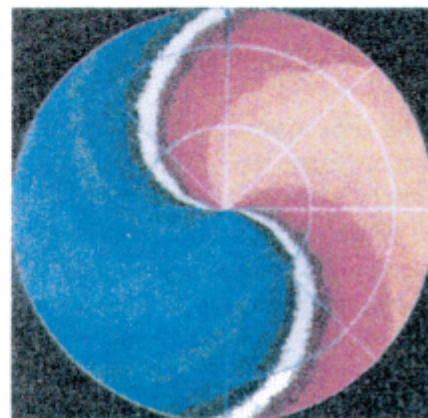
Figure 2-36.—(A) Vertical wind profile, (B) Horizontal wind profile, (C) Basic interpretation of display, (D) Doppler velocity display.

would appear in the horizontal. View (C) is a basic interpretation of wind direction along the zero-Doppler line where the small arrows represent wind vectors. The orientation of the zero-Doppler line in this figure indicates the wind direction is perpendicular to the radar beam at that particular azimuth. For example, along the outer edge of the display, the velocity is zero when the radar beam points to the north (point l), and to the south (point 3). This means that the wind is either blowing from west to east or east to west at the height corresponding to the edge of the display (remember the pseudo 3-D display). Since Doppler velocities are negative along the western side of the display and positive along the eastern side, the wind must be

THIS PAGE MUST BE PRINTED ON A COLOR PRINTER.

blowing from west to east at the height of the display. At point 2, the zero line is oriented east to west. In this instance, inbound velocities are to the south so the wind direction must be 180° near the surface.

Figure (D) is an example of the WSR-88D velocity display. As you can see, areas of red and orange indicate flow away from the radar, while areas of green and blue indicate flow toward the radar. The colors can then be compared to the color scale above to determine wind speed.

Again, successful coverage from this product depends on the size and amount of scatterers available. When ground clutter or anomalous propagation contaminate the radar beam, all velocities will be biased toward zero. When range folding occurs, purple shading might obscure valuable data, causing you to miss significant features. Keep in mind that all velocities are relative to the **RDA,** not the PUP.

DERIVED PRODUCTS

Derived products are enhanced renditions of base products that provide observers and forecasters with a unique perspective of radar information. In the following text, we will discuss some of the more commonly used derived products.

Composite Reflectivity (CR) Product

Recall that base reflectivity provides a "birds eye" view of the radar coverage area. While this is very useful, base products provide data from only a single elevation angle. Thus, only a slice of the overall atmosphere is presented, and valuable information above or below the radar beam may be overlooked. To sample the entire volume scan, radar operators must view each slice individually. This time-consuming process is impractical for the operational user. The WSR-88D offers Composite Reflectivity (CR) as a partial solution.

The CR product contains information found in base reflectivity. However, one very important difference exists:

composite reflectivity operates on a summation principle. That is, the algorithm first compiles data from all elevations (volumetric), and then produces a product which displays only the **strongest** returns for all regions of the radar coverage area. In building the CR product, the algorithm considers only intensity as its criteria. Size, shape, characteristic, and altitude are not factored.

The CR offers a "sneak-peek" advantage over base reflectivity, but should never replace the use of other reflectivity products. When using CR, operators are less likely to miss significant targets since only reflectivity maximas are displayed. The major downside of this product is its loss of target heights. This limitation poses serious problems since echo heights relate closely to storm development. Without height data, targets become deceiving. This product is normally accompanied by an attribute table that ranks storms according to severity and includes forecast movement and the likelihood of each storm to produce a variety of conditions (hail, mesocyclones, tornadoes, etc.).

Keep in mind that values displayed for a given location could have come from any altitude or elevation angle. In fact, extensive ground clutter may severely contaminate this product, creating the illusion of intense storms where nothing exists. This occurrence is common when superrefractive conditions are present. Figure 2-37 is an example of the Composite Reflectivity product.

Vertically Integrated Liquid (VIL) Product

Most WSR-88D products emphasize a target's horizontal details. The Vertically Integrated Liquid (VIL) product provides an estimate of atmospheric liquid-water content in the **vertical.** It serves a multitude of purposes, but is primarily designed to evaluate storm severity.

The VIL product is compiled from extensive reanalysis of base reflectivity data. It totals reflectivity within a given column of the atmosphere and then displays a product of tallied values. The function of the VIL algorithm is to estimate the amount of liquid water contained in a storm, and then display that value (kilograms/meter squared) in a graphical form. In its initial stages, the VIL algorithm holds many similarities to composite reflectivity. It builds a volumetric product by compiling reflectivity data from all elevation angles. The difference is that VIL displays tallied values for the entire column (fig. 2-38). CR displays only the reflectivity maxima regardless of altitude. Users can quickly evaluate storms by comparing VIL columns.

VIL is useful when monitoring general echo patterns for signs of development. In convective situations, VIL is directly related to updraft strength, which translates into storm severity. The VIL, product was designed to distinguish severe from nonsevere storms, but it is also used as a hail indicator (very high dBZs).